REMARKS

Applicants have amended their specification in order to provide consistency throughout the specification, as well as to provide consistency between the drawing figures and the specification. It is respectfully submitted that these amendments to the specification do not add new matter to the application.

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended various of the independent apparatus claims in the application (that is, claims 1, 2, 4 and 6) to recite that the heating device is a high-frequency induction heater including a high-frequency coil for heating the crucible. Furthermore, Applicants have amended the independent methods claims in the application (that is, claims 3 and 5) to recite that the crucible is heated by a high-frequency inductor heater including a high-frequency coil for heating the crucible. Applicants have also cancelled claim 12 without prejudice or disclaimer.

In addition, Applicants have added new claims 13-17 to the application. Claim 13, dependent on claim 2, recites that the apparatus further includes a heat conducting member which extends upward at least from the vicinity of the upper end portion of the side wall of the crucible, which surrounds a formed single crystal, and which is made of a material having heat conductivity. Thus claim 13 recites structure including both the heat conducting member and the radiation heat blocking member. Claim 14, dependent on claim 13, recites that the radiation heat blocking member is located at the upper end of the heat conducting member. In connection with claims 13 and 14, note, for example, Figs. 1 and 2 of Applicants' original disclosure. New claim 15, dependent on claim 2, recites that the apparatus includes a refractory member surrounding the crucible and extending above the crucible, with the

interface portion radiation heat blocking member being a lid portion of the refractory member. Note, for example, Fig. 3 of Applicants' original disclosure. Claims 16 and 17, dependent respectively on claims 4 and 16, respectively recites that the in-crucible radiation heat blocking member is a radiation heat shielding plate in a shape of a cone along the taper portion of the single crystal; and recites that an angle of inclination of the conical surface of the radiation heat shielding plate is substantially equal to the angle of inclination of the taper surface of the taper portion of the single crystal. Note, for example, Fig. 10 of Applicants' original disclosure, together with, for example, the description in connection therewith on pages 62 and 63 of Applicants' specification.

The objection to claim 12 as being in improper form, and the rejection of claim 12 under the second paragraph of 35 USC 112, as being indefinite, set forth in Items 2 and 3 on page 2 of the Office Action mailed October 3, 2006, are noted. Such objection and rejection are moot, in view of present canceling of claim 12.

However, the undersigned wishes to point out that a multiple dependent claim can be dependent upon another dependent claim, while still being a proper dependent claim. It is respectfully submitted that while a multiple dependent claim cannot be dependent upon another multiple dependent claim, it can be dependent upon a single dependent claim (where all claims upon which the multiple dependent claim ultimately depends are single dependent claims).

Moreover, the contention by the Examiner in the last paragraph on page 2 of the Office Action mailed October 3, 2006, that claim "2" is unpatentable under 35 USC 112, second paragraph, as being indefinite, is respectfully traversed. If this is a typographical error, and claim 12 is intended, then this rejection is moot as discussed previous, in light of cancelling of claim 12. It is respectfully submitted that

the Examiner has provided no basis for claim "2" being indefinite; and it is respectfully submitted that claim 2 as previously considered by the Examiner, and as presently amended, clearly satisfies the definiteness requirement of the second paragraph of 35 USC 112.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed October 3, 2006, that is, the teachings of the U.S. patents to Ikeda, No. 6,099,641, and to Ferry, et al., No. 6,482,263, under the provisions of 35 USC 103.

It is respectfully submitted that the references as applied by the Examiner would have neither taught nor would have suggested such an apparatus for producing a single crystal as in the present claims, having, inter alia, the crucible and heating device, and wherein the heating device is a high-frequency induction heater including a high-frequency coil for heating the crucible, and with the apparatus further comprising a heat conducting member which extends upwards at least from the vicinity of the upper end portion of the side wall of the crucible which surrounds a formed single crystal, and which is made of a material having heat conductivity (note claims 1 and 13); and/or wherein the apparatus includes an interface portion radiation heat blocking member for blocking, at least during cooling after formation of the single crystal, the radiation heat toward an upper portion above the interface portion between a taper portion and a cylindrical straight body portion (see claims 2 and 13); or wherein the apparatus, having the high-frequency coil for heating the crucible, includes (a) an in-crucible radiation heat blocking member which surrounds a single crystal end and which blocks the radiation heat from an inner surface of the crucible toward the single crystal positioned in the inside of the crucible, and (b) an

in-crucible radiation heat blocking member transporting device for transporting the in-crucible radiation heat blocking member in a vertical direction, to transport the in-crucible radiation heat blocking member to a position surrounding a taper portion of the single crystal during formation of the taper portion of the single crystal and to transport the in-crucible radiation heat blocking member to the position at a distance from the single crystal during formation of a straight body portion of the single crystal cylindrically grown connecting with the taper portion (see claim 4); and/or wherein the apparatus includes (a) a straight body portion radiation heat blocking member which can pass through a single crystal and which blocks the radiation heat toward an upper portion above the upper end portion of the crucible and (b) a straight body portion radiation heat blocking member transporting device for transporting the straight body portion radiation heat blocking member in a vertical direction, the straight body portion radiation heat blocking member transporting device transporting the straight body portion radiation heat blocking member to a position at a distance from the upper end portion of the crucible during formation of a taper portion of the single crystal and positions the straight body portion radiation heat blocking member in between the outer perimeter surface of the straight body portion of the single crystal and the inner perimeter surface of the crucible or in between the outer perimeter surface of the straight body portion of the single crystal and the upper end portion of the crucible during formation of the straight body portion of the single crystal cylindrically grown connecting with the taper portion (see claim 6).

Moreover, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such an apparatus for producing a single crystal as in the present claims, including a crucible and a high-frequency generation device including a high-frequency coil disposed

surrounding the crucible, and wherein the apparatus further comprises a wall-side heating member for heating a portion in between the upper end portion and lower end portion of the side wall of the crucible by operation of the high-frequency generation device (see claim 7); and/or wherein the apparatus includes a bottom-side heating member for heating a central portion of the bottom by operation of the high-frequency generation device, on the bottom of the crucible (see claim 8).

Furthermore, it is respectfully submitted that the teachings of these references as applied by the Examiner would have neither taught nor would have suggested such a method for producing a single crystal as in the present claims, including heating a crucible and pulling up a seed crystal while the seed crystal is in contact with a melt of raw material, wherein the crucible is heated by a high-frequency induction heater including a high-frequency coil for heating the crucible, and, furthermore, wherein the diameter of the single crystal is increased during formation of a taper portion of the single crystal in an initial stage of growth of the single crystal, the single crystal being cylindrically grown connecting with the taper portion during formation of a straight body portion of the single crystal, while the radiation heat which reaches the taper portion of the single crystal from an inner surface of the crucible is blocked during the formation the taper portion of the single crystal (see claim 3); or wherein the diameter of the single crystal is increased during formation of the taper portion, and the single crystal is cylindrically grown connecting with the taper portion, while the radiation heat toward an upper portion above the upper end portion of the crucible is blocked during the formation of the straight body portion of the single crystal (see claim 5).

Moreover, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such apparatus

as in the present claims, having features as discussed previously, and, additionally (but not limited to) wherein the radiation heat blocking member is located at the upper end of the heat conducting member (see claim 14); and/or wherein the apparatus further includes a refractory member surrounding the crucible and extending above the crucible, with the interface portion radiation heat blocking member being a lid portion of the refractory member (see claim 15); and/or wherein the in-crucible radiation heat blocking member is a radiation heat shielding plate in a shape of a cone along the taper portion of the single crystal (see claim 16), especially wherein an angle of inclination of the conical surface of the radiation heat shielding plate is substantially equal to the angle of inclination of the taper surface of the taper portion of the single crystal (see claim 17).

In addition, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such apparatus as in the present claims, having features as discussed previously in connection with claims 7 and 8, and, additionally, wherein the wall-side heating member includes a protrusion-shaped member made of an electrically conductive material and which is disposed in between the upper and lower end portions of the outer surface of the side wall of the crucible while extending along the circumferential direction of the outer surface of the side wall of the crucible (see claim 9); and/or wherein the bottom-side heating member comprises a heat conducting portion made of a heat conductive material for conducting heat to a central portion of the outer surface of the bottom of the crucible and a board-shaped heat generation portion which has a diameter larger than the diameter of the heat conducting portion which is made of an electrically conductive portion (see claim 10); or wherein the bottom-side heating member includes a heat insulating member made of a heat insulating material

having a through hole at a position in accordance with a central portion of the outer surface of the bottom of the crucible and a board-shaped heat generation portion which has a diameter larger than the diameter of the through hole of the heat insulating member and which is made of an electrically conductive material (see claim 11).

The present invention is directed to a technology of producing a single crystal (for example, but not to be limited to, a single crystal of semiconductor material) used for various technologies.

In a known technology of producing a single crystal, a seed crystal is brought into contact with a melt of a heated raw material, and this seed crystal is pulled up, so that a single crystal is produced. According to known techniques, initially a tapered portion is grown from the seed crystal; and when the diameter of the seed crystal reaches a predetermined size, formation of the tapered portion having a diameter becoming gradually increased is terminated, and formation of a straight body portion is started.

In producing a single crystal, when defects, cracks and the like occur in the single crystal, portions including the defects, cracks and the like become defective portions, thereby reducing yield and effectiveness of the process. Therefore, it is necessary, in order to improve productivity, to reduce the occurrence rate of such defective portions.

It has been found that a temperature distribution in the single crystal in the longitudinal direction during the formation of the single crystal and during the cooling of the single crystal is a cause for such defective portions, and various techniques have been proposed for improving temperature distribution so as to avoid such defective portions, as described on pages 3-6 of Applicants' specification.

In addition, it has been proposed to use a high-frequency induction heating in order to heat the crucible for melting material to be formed into the single crystal. However, additional problems arise in connection therewith, with respect to defects and cracks, as well as other defective portions, being formed in the single crystal produced.

Against this background, Applicants provide apparatus and method which avoids such defects, cracks and the like, in producing a single crystal by pulling the single crystal using a seed crystal, and which avoids such problems even when using a high-frequency coil for heating the crucible.

According to one feature of the present invention, Applicants have found that through use of the heat conducting member as in various of the present claims, defects due to temperature differences in the radius direction of the single crystal is reduced. Note, in particular, the sole full paragraph on page 9, and the sole full paragraph on page 10, of Applicants' specification.

Applicants have further found that according to another aspect of the present invention, by use of a radiation heat blocking member of an interface portion between a taper portion, which is connected with the seed crystal of the formed single crystal, and a cylindrical straight body portion, the problem of defects, cracks and the like can be reduced. Note, for example, pages 10-12 of Applicants' specification.

Applicants have also found that another cause of the occurrence of defects, cracks, and the like was attributed to the occurrence of roughening of the surface resulting from an excessive rise in the temperature of the taper surface of the tapered portion during the formation of the single crystal; and that it is effective for suppressing such roughening to suppress the temperature rise of the taper surface

of the tapered portion during the formation of the tapered portion in an initial stage of growth of the single crystal, while the tapered portion of the single crystal is positioned in the inside of the crucible. Note, for example, pages 12-14 of Applicants' specification.

Applicants have still further found that the occurrence of such defective portions can be further reduced through use of an in-crucible radiation heat blocking member which blocks the radiation heat from an inner surface of the crucible towards the single crystal positioned in the inside of the crucible, together with use of an in-crucible radiation heat blocking member transporting device for transporting this radiation heat blocking member in a vertical direction, to surround a taper portion of the single crystal during formation of the taper portion and transports this blocking member to a position at a distance from the single crystal. By such technique, including use of the transporting device, heating of the taper surface can be suppressed; while, on the other hand, in formation of the straight body portion of the single crystal the outer perimeter surface of the straight body portion is applied with radiation heat from the inner surface of the crucible, and, thereby, a temperature drop of the outer perimeter portion of the straight body portion of the single crystal is reduced, so as to reduce temperature difference in the radius direction of the single crystal. Note, in particular, pages 14 and 15 of Applicants' specification. See also pages 17-19 of Applicants' specification.

As further features according to the present invention, by utilizing wall-side and bottom-side heating members as in the present claims, more uniform temperature distribution can be achieved, and undesired convection patterns of melted material for the single crystal, can be avoided, providing additional bases for avoiding the defective portions discussed previously. See pages 19-21 of

Applicants' specification. Note also pages 33-39 of Applicants' specification, further describing advantages of the present invention.

Ikeda discloses a method and an apparatus for pulling a single crystal, by the Czochralski method, wherein a single crystal is pulled by dipping a seed crystal into a melt formed in a quartz crucible, with a local highest temperature of the quartz crucible being 1600°C or less. See column 2, lines 28-33. This patent discloses use of heaters for heating a melt in a quartz crucible, wherein the melt is directly heated by heaters arranged above the quartz crucible. Note column 2, lines 38-50. Note also column 3, lines 1-5, 10, 11, 20-25 and 37-40.

It is respectfully submitted that Ikeda would have neither taught nor would have suggested various aspects of the present invention, including use of the high-frequency induction heater, or the heat conducting member, positioned as in the present claims, and/or the interface portion radiation heat blocking member, and/or the in-crucible radiation heat blocking member, or the heat blocking member transporting device, and/or wall-side or bottom-side heating members, as in the present claims; and/or method aspects of the present invention, including use of the high-frequency induction heater, or wherein radiation heat which reaches the taper portion of the single crystal of an inner surface of the crucible is blocked during the formation of the taper portion of the single crystal, or wherein radiation heat toward an upper portion above the upper end portion of the crucible is blocked during formation of the straight body portion of the single crystal, and/or other features of the present invention as discussed previously, and advantages thereof.

It is respectfully submitted that the teachings of the other reference applied by the Examiner, Ferry, et al., would not have rectified the deficiencies of Ikeda, such

that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Ferry, et al. discloses a crystal pulling apparatus for growing single crystal semiconductor material, including a heat shield assembly for use in crystal puller apparatus for increasing the axial temperature gradient of single crystal semiconductor material grown in the apparatus. The heat shield assembly includes a reflector which comprises a tubular structure adapted for positioning generally within the heat shield assembly and having a central opening sized and shaped for surrounding the ingot produced by the crystal puller. An outer surface of the tubular structure is adapted for placement in opposed relationship with the heat shield assembly, and is constructed of a material having a low emissivity. The outer surface of the tubular structure has a spacer projecting outward therefrom for contacting the heat shield assembly to space the outer surface of the tubular structure from the heat shield assembly. Note column 2, lines 53-65. See also column 3, lines 15-29, for disclosure of a crystal puller utilizing the aforementioned heat shield assembly. See also column 3, lines 51-54; column 3, line 66 through column 4, line 1; column 4, lines 12-22, 34-43 and 50-55; and column 6, lines 54-64.

Even assuming, arguendo, that the teachings of Ferry, et al. were properly combinable with the teachings of Ikeda, it is respectfully submitted that the combined teachings of these references would have neither taught nor would have suggested the apparatus and method as in the present claims, including use of the heating device which is a high-frequency induction heater including a high-frequency coil, and particular problems arising in connection therewith; and/or use of the various heat blocking members, providing advantages as discussed previously, and/or use of the heat conducting member, providing advantages as discussed previously;

and/or wherein the apparatus includes the wall-side heating member and/or bottom-side heating member, and advantages thereof, as discussed previously.

The contention by the Examiner in Item 9 on page 4 of the Office Action mailed October 3, 2006, that the difference between Ikeda and the present invention is that Ikeda does not teach a heat-shielding member, is noted. It is respectfully submitted, however, that there are many more differences between Ikeda and the presently claimed invention, as discussed in the foregoing, including the heat conducting member, the interface portion radiation heat blocking member, the radiation heat blocking member transporting device, and wall-side and bottom-side heating members, and methods of use, as well as advantages thereof, as discussed in the foregoing.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the application, are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 389.44535X00), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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